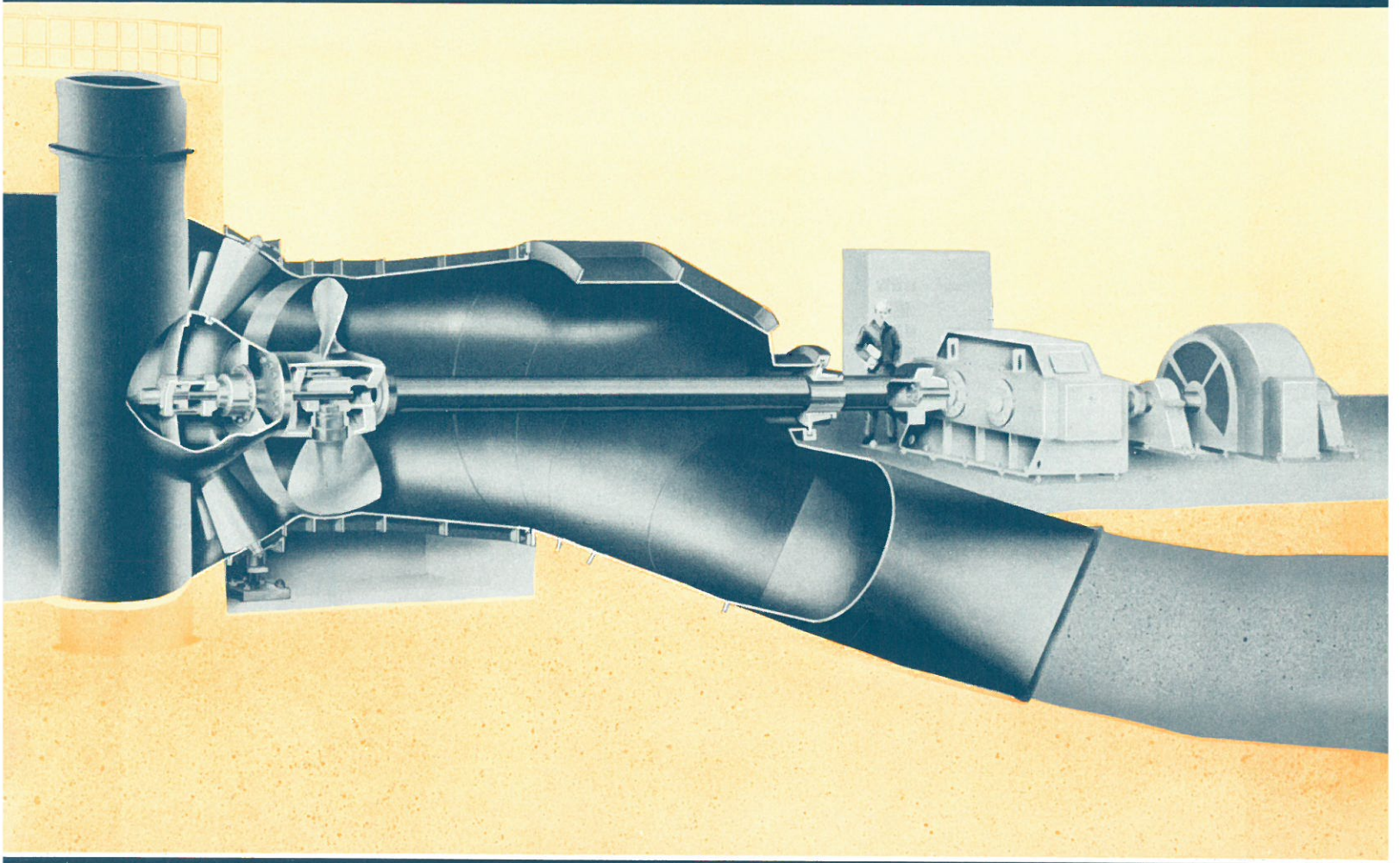
ALLIS-CHALMERS

Standardized Gated TUBE Turbine Generating Units



This packaged generating unit can produce maximum annual energy from varying flow and heads. Use of wicket gates with the Standardized TUBE turbine unit provides a wide operating range at maximum efficiencies — at both high output and part load. Automatic coordinated positioning of blades and gates permits the widest operating range for low head hydro plants where operating conditions often involve both varying flow and head.

PACKAGED HYDROELECTRIC UNITS keep

Allis-Chalmers builds standardized generating units to provide economical hydroelectric power from flowing water — a naturally renewable energy source. As costs for fossil fuels increase, the benefit versus cost ratio becomes more favorable for developing new hydro power sites or refurbishing existing sites.

TUBE turbines are propeller-type units which provide the highest possible operating speed and maximum capacity for a given physical size. The powerhouse structure may be eliminated or substantially reduced in size, minimizing the need for deep foundations and reducing civil construction costs. The building can be blended into the dam and its surroundings or located underground or within the dam. Thus, the standardized TUBE turbine concept permits maximum flexibility in arrangement and operating characteristics.

Packaged Units

These pre-engineered hydroelectric generating units cover a wide range of heads and flows. The units are complete including controls, permitting single source coordination with one experienced supplier, Allis-Chalmers. This coordination enhances economic and on-time development of energy resources at new sites or sites where outdated equipment is wasting energy.

Benefits of Standardization

Modern pre-designed TUBE turbines provide predictable, reliable installations at a lower cost per kilowatt. By standardizing the TUBE turbine, pre-engineering the equipment selection, employing experienced consulting engineers and keeping construction extras to a minimum, low head power plants can be built rapidly and at a competitive cost with other energy sources.

Modernization

The packaged units are especially adaptable to upgrading and/or enlarging older power plants and are designed to be utilized in existing waterways with a very minimum of civil construction.

Exclusive Design Features/Benefits

- EARLY DELIVERY — projects can often proceed from exemption or licensing to power production in twelve to eighteen months.
- SIMPLICITY OF DESIGN — standard commercial components are used for easy procurement and readily available service.
- ECONOMICAL INSTALLATION — civil construction is minimized and equipment installation is simplified.
- MAXIMUM ACCESSIBILITY — routine inspection and maintenance of components is convenient.
- FLEXIBLE APPLICATION — intake and draft tube can be readily adapted to site conditions and different settings can be accommodated.
- HIGH RELIABILITY — use of proven components and design features assure dependable service.
- SOLID ENGINEERING BACKGROUND — an extensive history of design, test and manufacturing experience backs these units.

Experience

More than ninety TUBE turbine units have been designed and manufactured by Allis-Chalmers with runner sizes as small as 14" diameter and as large as 315" diameter, having heads higher than 60 ft. and outputs exceeding 30,000 kW.

Four of the largest Allis-Chalmers projects with gated TUBE turbine units are:

1. Ozark Lock & Dam in Arkansas; 5 units, each rated at 25,200 kW, 32.3 ft. head.
2. Chaudiere #2 Plant in Quebec, Canada; one unit rated at 10,400 kW, 38 ft. head.
3. Webbers Falls in Oklahoma; 3 units, each rated at 23,050 kW, 26.5 ft. head.
4. Harry S. Truman Dam in Missouri; 6 pump/turbine units, each rated 31,630 kW, 42.5 ft. head.

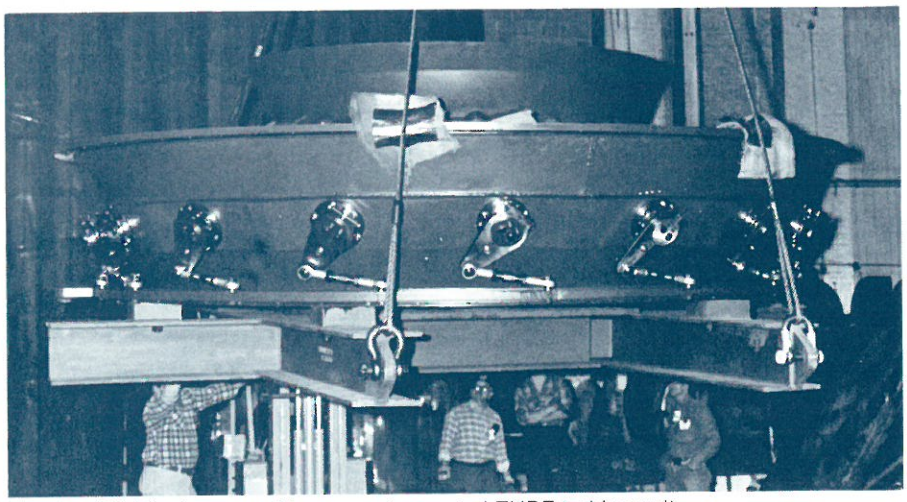


Fig. 1 — Distributor assembly as used on gated TUBE turbine unit

Sizing Criteria

Turbine performance characteristics are required to predict annual energy. Turbine model tests quantify efficiency, flow and power as a function of head and operating speed. Test results are summarized on a turbine performance hill curve (Figure 2). Allis-Chalmers has extensively tested the gated TUBE turbine product line for efficiency, flow and power in its advanced hydraulic laboratories in York, PA. These tests have been witnessed by recognized hydraulic industry experts.

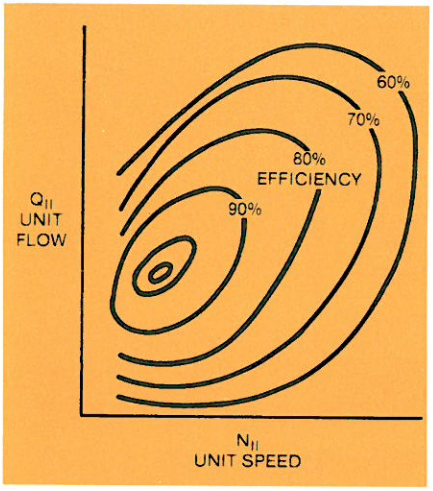


Fig. 2 — Performance characteristics summarized in coefficent form.

Since most small turbine installations are installed for new energy production rather than for additional capacity, it is important to estimate the annual energy contributed. In order to do this, the following information about the site is needed: (Figure 3)

A. How flow varies with time (flow duration). It is recommended that at least ten (10) years of data be used.

B. How headwater and tailwater elevations vary with the flow.

C. The type of operation planned.

With the above information, a mathematical model can be prepared which simulates the operation of the turbine/generator and calculates the energy production. This mathematical model takes into account the various turbine characteristics such as the cavitation and power limits.

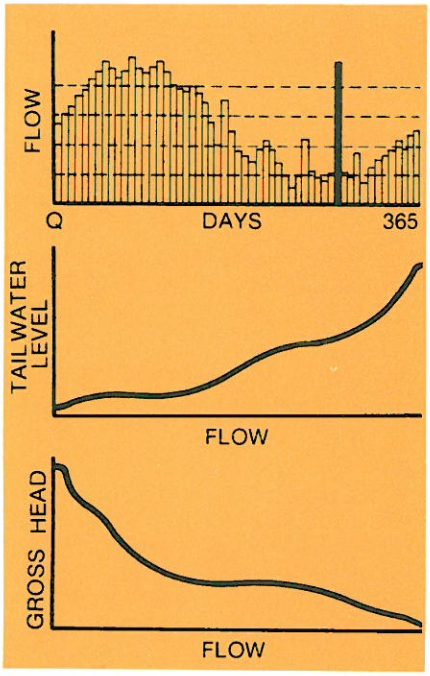


Fig. 3 — Some characteristics required to calculate annual energy.

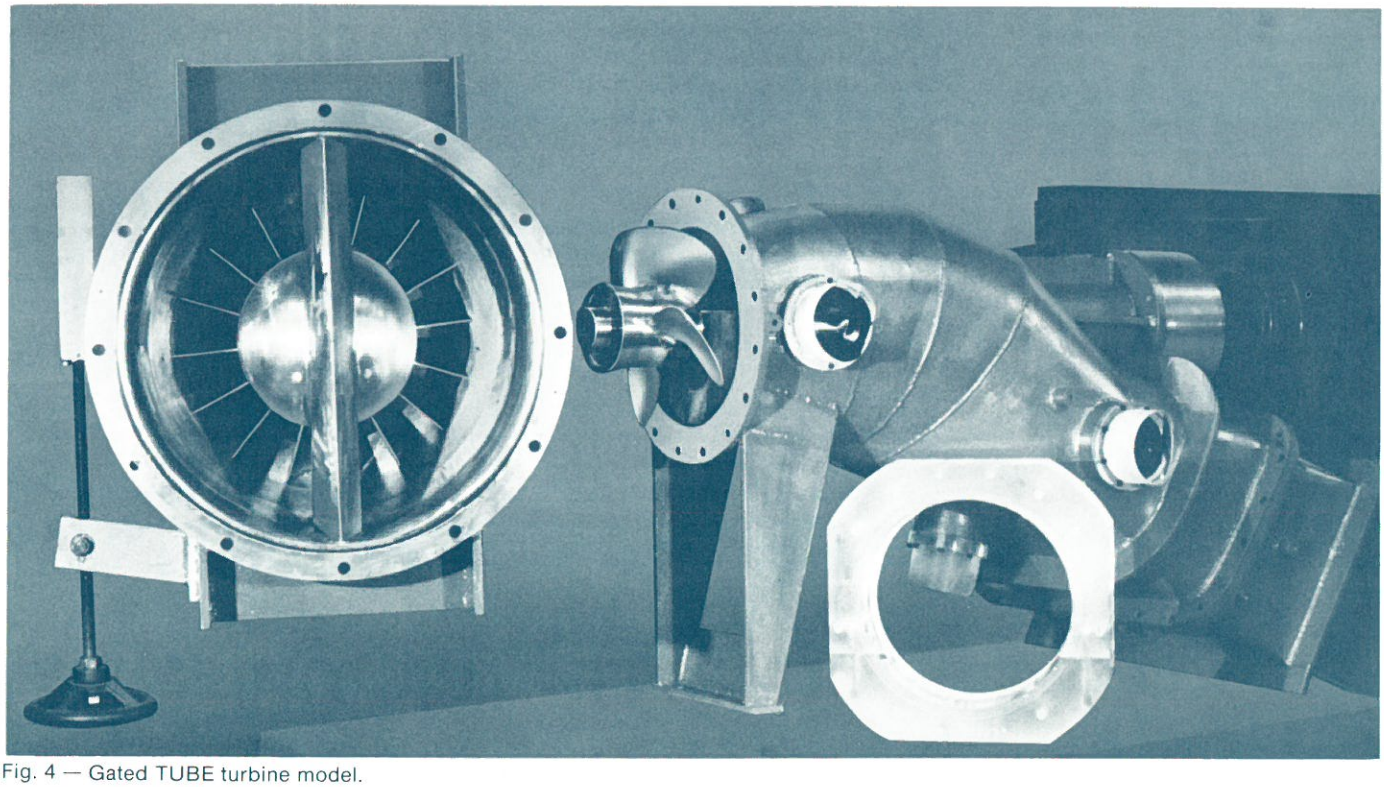


Fig. 4 — Gated TUBE turbine model.

Gated TUBE turbines can be utilized in projects

Chace Mill

City of Burlington, Vermont
Two units, 6500 kW
56.4 ft. net head

The long penstock necessitated careful analysis of hydraulic transients. Black start capability was required for a predefined load schedule.

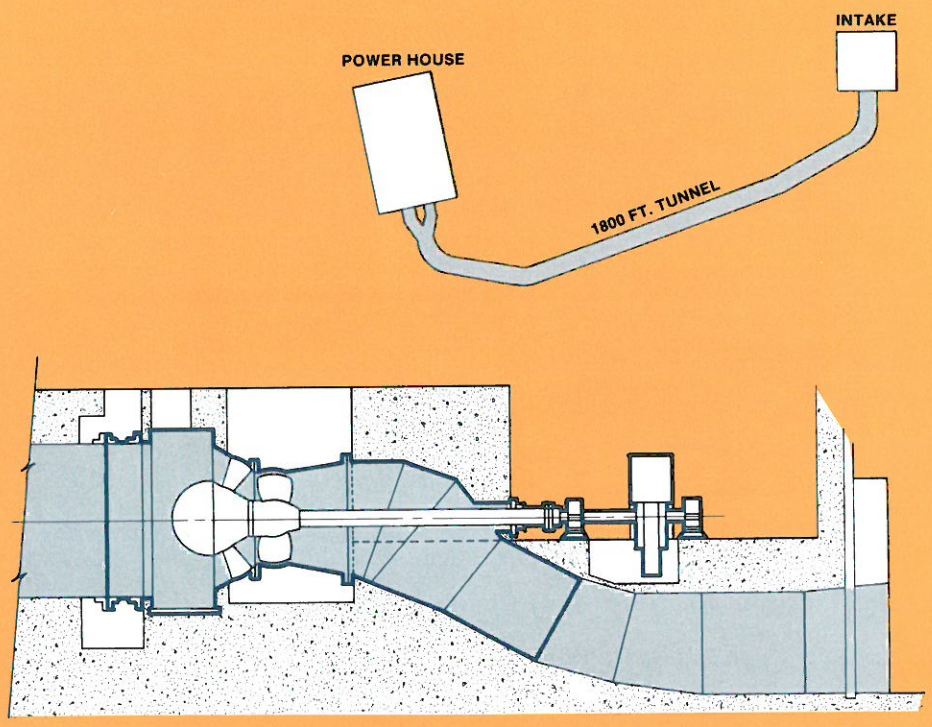


Fig. 5

Ware Shoals

Riegel Textile Corporation
South Carolina
One unit, 3088 kW
57.7 ft. net head

Original S. Morgan Smith turbines were in pressure cases. Two runners on a draft chest provided 1200 kW. One vertical Smith Kaplan turbine added 2500 kW. One modern gated TUBE turbine now replaces two original horizontal units.

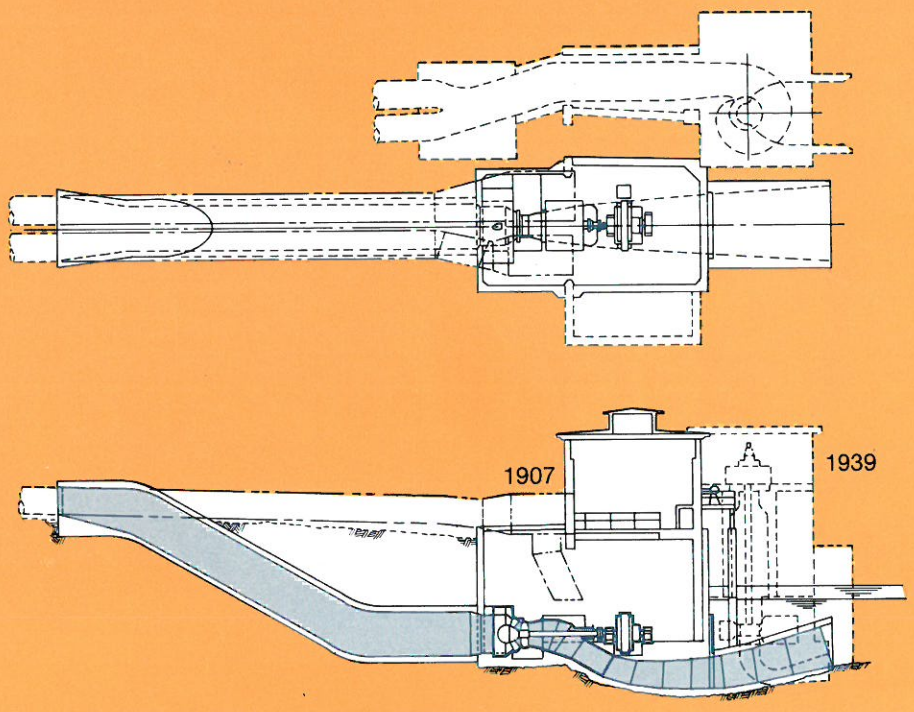
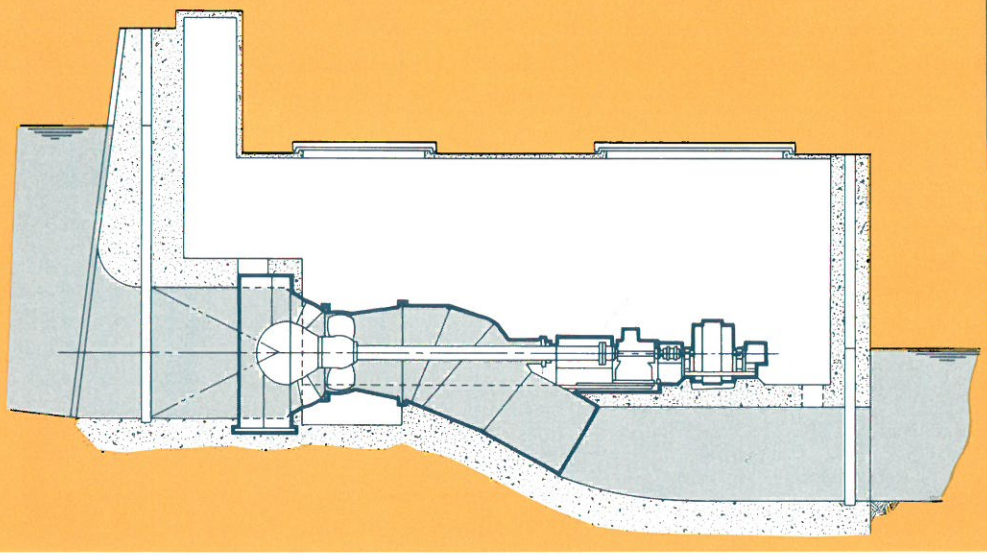


Fig. 6

with a broad range of specific requirements.

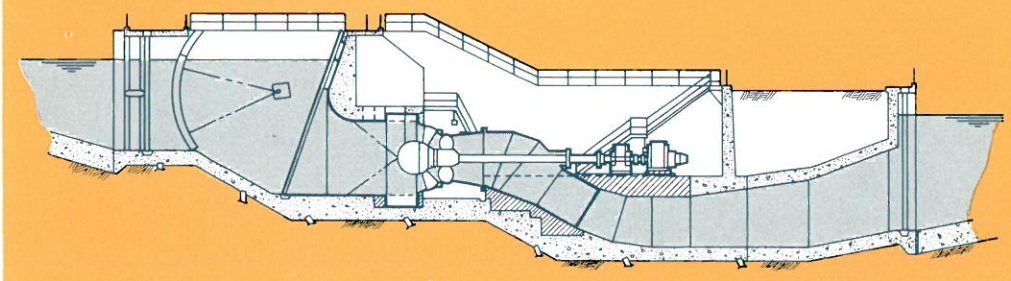


Penacook Lower Falls

New Hampshire Hydro Associates
One unit, 4115 kW
32.8 ft. net head

New spillway, dam and powerhouse are now part of this low head project. Negotiated contracts and a team approach improved project results.

Fig. 7

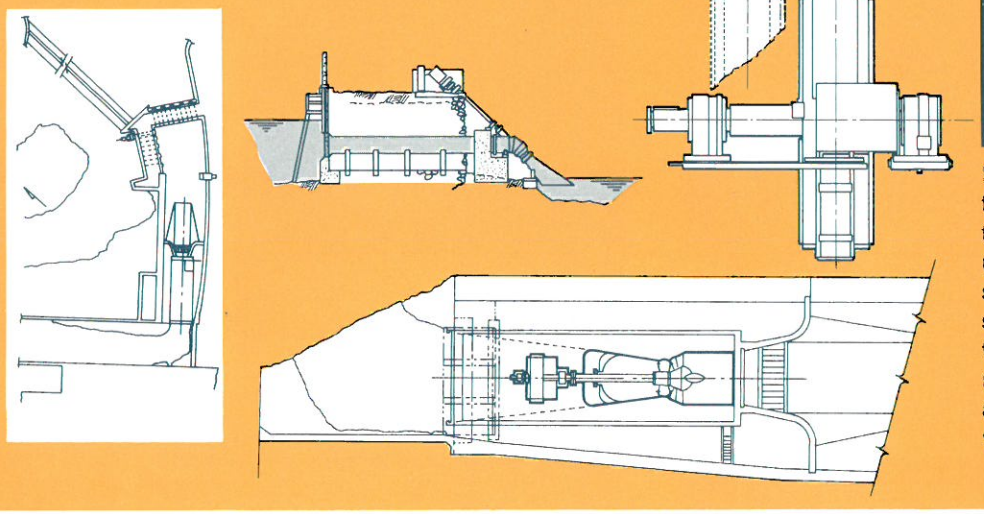


East Highline Turnout

Imperial Irrigation District
California, One unit,
2415 kW 16.0 ft. net head

Irrigation water supply control is provided at an existing structure. No powerhouse was required at this low head site.

Fig. 8



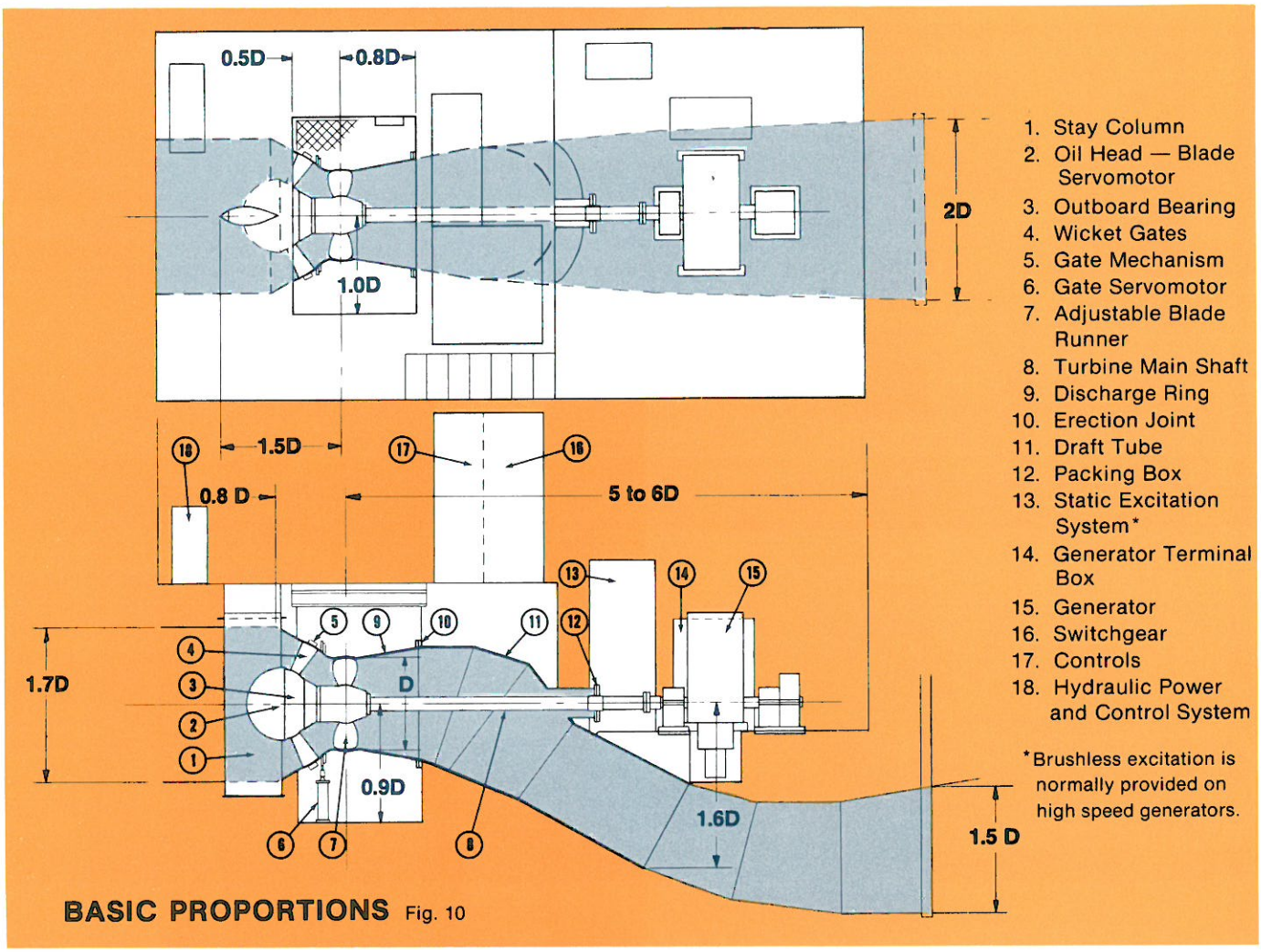
Wyre Wynd

Southwire Co.
Jewett City, Connecticut
One Unit, 2660 kW
19.0 ft. net head.
Mini TUBE Turbine 71 kW
13.1 ft. net head

Existing structures lead to a unique layout. Stator shift on the larger unit facilitated rotor and stator inspection and service. A mini TUBE turbine provides energy recovery at dam where a minimum discharge was required.

Fig. 9

Basic Proportions



BASIC PROPORTIONS Fig. 10

Fig. 11 — Lower Penacook Falls

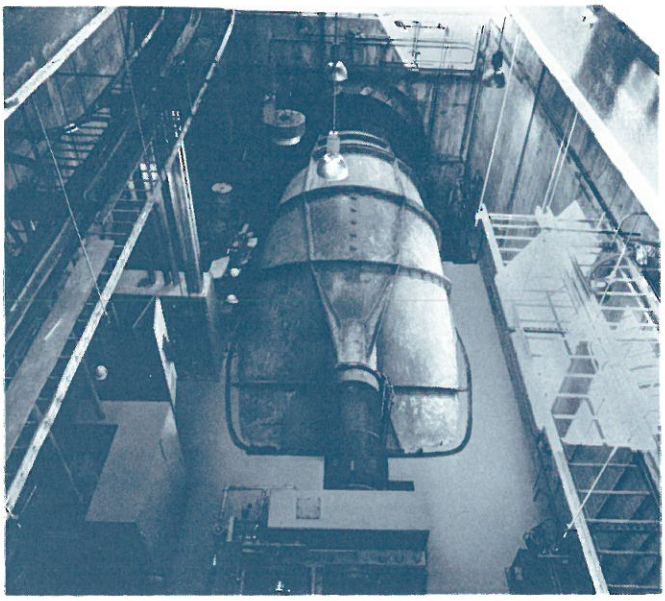
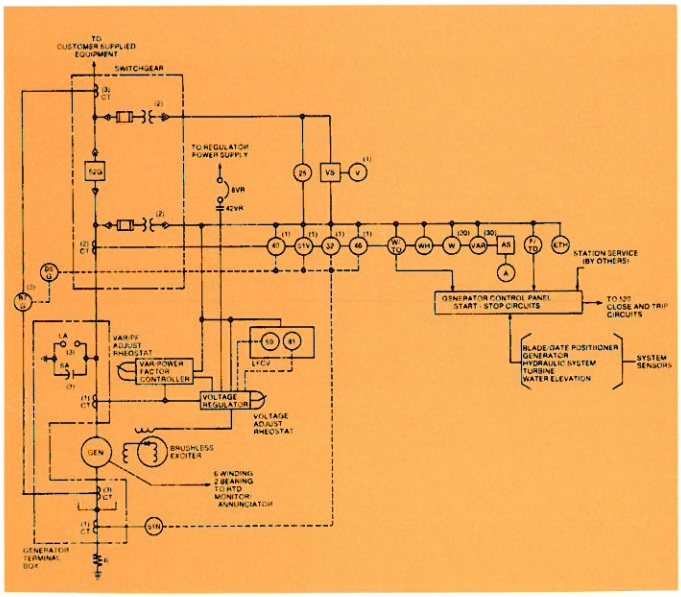


Fig. 12 — Typical electrical system diagram.



Component Description

MECHANICAL:

Wicket Gates will serve not only as the primary closure device but also as a flow control system that establishes turbine output. A hydraulic cylinder positions the wicket gates such that they control turbine speed during start-up. Once the generator is connected to the line, wicket gates control flow such that the turbine/generator output meets either the flow or load requirements. For normal turbine shutdown or loss of load, the wicket gates will close and provide the primary means of water shut off. A secondary closure device such as stop logs, or on very long pipe lines, an intake gate may also be necessary. In addition to adjustable wicket gates, the hydraulic turbine may have adjustable runner blades in order to optimize efficiency at both part load and maximum output. Both the adjustable runner blades and wicket gates are actuated by a hydraulic positioner with oil pressure provided by a hydraulic power system which includes motor driven oil pump, controls, valves, reservoir and accumulator.

Stay Column is a streamlined support for the wicket gate inner barrel and upstream runner stub shaft. The stay column provides access to the outboard bearing and runner oil head. The outboard turbine bearing is a self-aligning spherical or tapered roller type. This bearing carries radial loads imposed by the turbine. It can compensate for misalignment of up to 1.5°, has a minimum L-10 life of 100,000 hours and is oil bath lubricated. The main turbine shaft extends downstream through a floating packing box mounted on the draft tube elbow. The draft tube is of the high energy recovery, elbow type, fabricated from plate steel. Stiffening ribs are provided to minimize distortion and vibration. A section is removable (bolted) for access or removal of the runner, shaft and wicket gates. The shaft packing box has an adjustable gland and uses conventional woven square packing.

Runner may be of either the fixed blade or adjustable blade type with steel hub and stainless steel blades. The adjustable blade operating mechanism consists of steel levers attached to the blade trunnions. The levers are connected by steel links to the crosshead which interlocks all blades at the same angle. It is positioned by a hydraulic blade positioner located upstream of the turbine runner. The runner hub linkage and blade trunnions are supported on bronze bushings which are lubricated by oil from within the hub.

Speed Increaser when economically justified, will be located between the main turbine shaft and the generator to provide a suitable step up ratio from the design turbine speed to the generator speed. When included, the speed increaser will contain the turbine downstream guide and thrust bearing which will have a minimum L-10 life of 100,000 hours. The housing will be of steel construction reinforced in high load areas. All shafts will comply with limits set by the American Gear Manufacturers Association (A.G.M.A.) for shaft stresses, finishes and tolerances.

When a speed increaser is not economically justifiable, the turbine will be directly connected to the generator shaft flange. The generator bearings will be designed to accommodate the hydraulic turbine rotating weights and hydraulic thrust loads.

ELECTRICAL:

Generator may be either of the synchronous or induction type depending on the relative economics and system limitations. Generators comply with ANSI, NEMA and IEEE standards, and are designed to withstand the turbine runaway speeds. Drip-proof enclosures, with guard screens and oil lubricated bearings are usually used, and the generators are generally self-ventilated with internal fans. Full load temperature rise is a conservative 80° C by resistance with Class F insulation. Space heaters prevent condensation during shutdown periods. Generator accessories when specified, such as winding and bearing temperature detectors, surge capacitors, lightning arrestors and power factor correction capacitors, will be provided when specified.

Switchgear for a synchronous generator includes a horizontal drawout air circuit breaker, PT's, CT's, control power transformers and necessary fuses, switches, indicators, heaters, receptacles and key interlocks.

Transformer may be included to provide step-up from the generator voltage to the transmission voltage and can be throat connected to the switchgear. The high voltage side can be provided with suitable bushings for connection by others. The transformer is oil-to-air cooled and may have forced air provisions.

Load Switch Enclosure includes a load break disconnect switch, protective fuses, lightning arrestors, terminals for utility connection and space for utility metering equipment. The enclosure has front doors and key interlocks.

Control, Monitoring, and Protection Cabinet contains a programmable controller, indicating, control and monitoring devices. Automatic and remote controls or any modifications to standard components can be provided at extra cost.

Information Required for the Application and Selection of Hydraulic Turbines

Our complete facilities are at the service of water power users. We provide recommendations, layouts and proposals for both new developments and the reconstructing of existing plants. However, proper selection and application requires detailed, specific information. To prepare a complete proposal promptly, it is important that the following data, where applicable and available, be sent with each inquiry.

1. Name, firm or corporation, with address.
2. Location and name of the plant.
3. Approximate elevation of the plant above sea level.
4. Total quantity of water in cubic feet or cubic meters per second; with comments regarding the variations in daily and seasonal flow, as well as storage capacity. Flow duration curves and drainage area.
5. Quality of the water. Does it contain sand, chemicals or other impurities?
6. Gross head (vertical distance from the headwater level to the tailwater level) with any known variations preferably correlated with flow.
7. If already determined, net or effective head on which all guarantees are to be based, with any known variations. (If it has not been determined, we are prepared to estimate the net effective head based on the penstock or flume dimensions.)
8. Amount of power desired or required.
9. Discharge or load at which maximum efficiency is desired.
10. Number and size of the units contemplated or required now and for future installation. If new units are to be sized for an existing plant, give space limitations and details of existing foundations and superstructure.
11. Distance from normal tailwater level to powerhouse floor, with variations and relation to flow.
12. Proposed length, diameter and material of the supply pipe (penstock) if required. If already designed or installed, give complete information.
13. If a surge tank is installed or contemplated on the pipeline, the distance along the penstock from the surge tank to the powerhouse and all available surge tank data.
14. Will the plant operate separately or in parallel with a power system? If in parallel, give approximate installed capacity of the system and its frequency.
15. Method of intended operation —manual, semi-automtic, fully automatic or remote control.
16. Supplementary information with drawings or sketches, to assist in proper interpretation of the data.

Since many dimensions may be changed before the plant is actually constructed, the purchaser must be responsible for the net effective head, the elevations of the head and tailwater levels, and the quantity of water, as well as the exactness of all field information on which the final design of the turbines is based.

Additional types of hydro-turbines — Kaplan, Propeller, Impulse, Francis, Bulb, Reversible Pump/Turbine — are designed, manufactured, serviced and supplied by Allis-Chalmers.

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The information contained herein is general in nature and is not intended for specific construction, installation, or application purposes. Allis-Chalmers reserves the right to make changes in specifications shown herein or add improvements, or discontinue manufacture at any time without notice or obligation.

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